

## The Ara OB 1a Association

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**Abstract.** The Ara OB1a association is one of the closest sites where triggered star formation is visible for multiple generations of massive stars. At about 1.3 kpc distance, it contains complex environments including cleared young clusters, embedded infrared clusters, CO clouds with no evidence of star formation, and clouds with evidence of ongoing star formation. In this review we discuss the research on this region spanning the last half-century. It has been proposed that the current configuration is the result of an expanding wave of neutral gas set in motion between 10–40 million years ago in combination with photoionization from the current epoch.

### 1. Historical Summary (1960–1985)

Ara OB1a, while somewhat enigmatic, may be one of the best examples of triggered star formation in the local Galaxy. The triggering in the most active portion is easily imagined from images of the  $< 3$  Myr NGC 6193/RCW 108-IR complex such as Figure 1. However the full association may be as much as 50 Myr in age and cover several degrees on the sky. Ara OB1 was first studied in detail by Whiteoak (1963). He used photographic photometry and objective prism spectroscopy to identify about 35 O and B star members. Whiteoak's work was a follow up to an  $H\alpha$  survey by Rodgers, Campbell & Whiteoak (RCW; 1960), which cataloged 181  $H\alpha$  emission regions in the southern sky, including RCW 108. NGC 6193 is an open cluster, discovered by James Dunlop in 1826, that is dominated by a pair of O stars, HD 150135 and HD 150136. These are the brightest optically revealed O stars in the association and are thought to be responsible for ionizing the bright rim of emission to the west (NGC 6188, discovered by John Herschel in 1836) which separates NGC 6193 from RCW 108-IR. The youth of the region is clear in sky survey plates and Figure 1 which show concurrent regions of ionized gas and dust lanes. Whiteoak noted two additional clusters in the region, NGC 6204 – about 2 degrees to the northeast – and NGC 6167 – about 1 degree to the southwest.

Ara OB1a is a compact association covering about 1 sq. degree around a central cluster – NGC 6193. It is generally thought to be about 1.3 kpc away and can be equated with RCW 108. There is some confusion in the literature as to what is actually meant by RCW 108. The original definition of Rodgers, Campbell & Whiteoak (1960) refers to all the region where  $H\alpha$  nebulosity is detected, for which they give a size of  $210' \times 120'$  centered at  $(l, b = 336.49, -1.48)$ . Straw et al. (1987) used RCW 108–IR to refer to the embedded IR cluster about  $15'$  to the west of the O stars in NGC 6193 and which is identified with IRAS 16362–4845. The confusion arises when RCW 108–IR is abbreviated by dropping the “–IR”. For the remainder of this paper we will refer to the embedded cluster as RCW 108–IR or IRAS 16362–4845.

Moffat & Vogt (1973) measured photometry for 13 stars within  $4'$  of the center of NGC 6193 and found  $E_{B-V} = 0.4$  and a distance of 1360 pc. Herbst & Havlen (1977) describe Ara OB1 as having a “diamond ring” appearance, with RCW 108–IR as the “diamond” and a thin circular dust ring making up almost half of the “ring”. They performed photoelectric and photographic photometry on 702 stars in the region. Herbst (1974, 1975) identified parts of this region as an “R association” as there were three early type stars associated with reflection nebulosity. These stars may mark a separate site of star formation within Ara OB1a. We will discuss this further in Section 6.

Mid-infrared MSX & IRAS maps of the region show several condensations. The brightest is coincident with RCW 108–IR and two apparently related peaks IRAS 16379–4856 and IRAS 16348–4849. One of the earliest radio studies of the region was in the survey by Shaver & Goss (1970). They made a 5 GHz and 408 MHz survey of over 250 Galactic radio source including RCW 108. RCW 108 was remarkable for having one of the smallest emission regions – unresolved at  $3'$  and having a relatively high density and temperature of the electron population.

In addition to Ara OB1a, Whiteoak (1963) identified a background O star cluster coincident with NGC 6193 but with a different distance modulus. While the foreground Ara OB1a has a distance modulus of  $10.5 \pm 0.6$  the second group of about 13 O and B stars (Ara OB1b) has a distance modulus of  $12.7 \pm 0.5$  or about 3500 pc. The central O stars of the two associations are offset by about  $2^\circ$  along the Galactic plane (Humphreys 1978), so this is a concern for membership determination.

## 2. NGC 6193

NGC 6193 is the open cluster to the east of the bright emission rim NGC 6188. In this region, Herbst & Havlen (1977) measured over 700 stars photometrically. Of these, 59 had photometric distances and reddening consistent with cluster membership. This appears to be complete to earlier than A0. This survey covered an area about  $40'$  on a side. They found a slightly steeper than usual reddening law. Their best-fit photometric distance was  $1320 \pm 120$  pc. Several other groups have estimated the distance to the cluster using photometric parallax techniques and obtain results ranging from  $\approx 1100$  to  $\approx 1400$  pc (Moffat & Vogt 1973, Fitzgerald 1987, Kalcheva & Georgiev 1992). Vazquez & Feinstein (1992) obtained an age of about 3 Myr by fitting the upper main sequence, they also determined a distance of about  $1410 \pm 120$  pc using an  $R = 3.1$  reddening law. They noted that the steep reddening found by Herbst & Havlen (1977) was due to a binarity-induced color shift. Extinction is low ( $A_V \sim 0.5$ ).

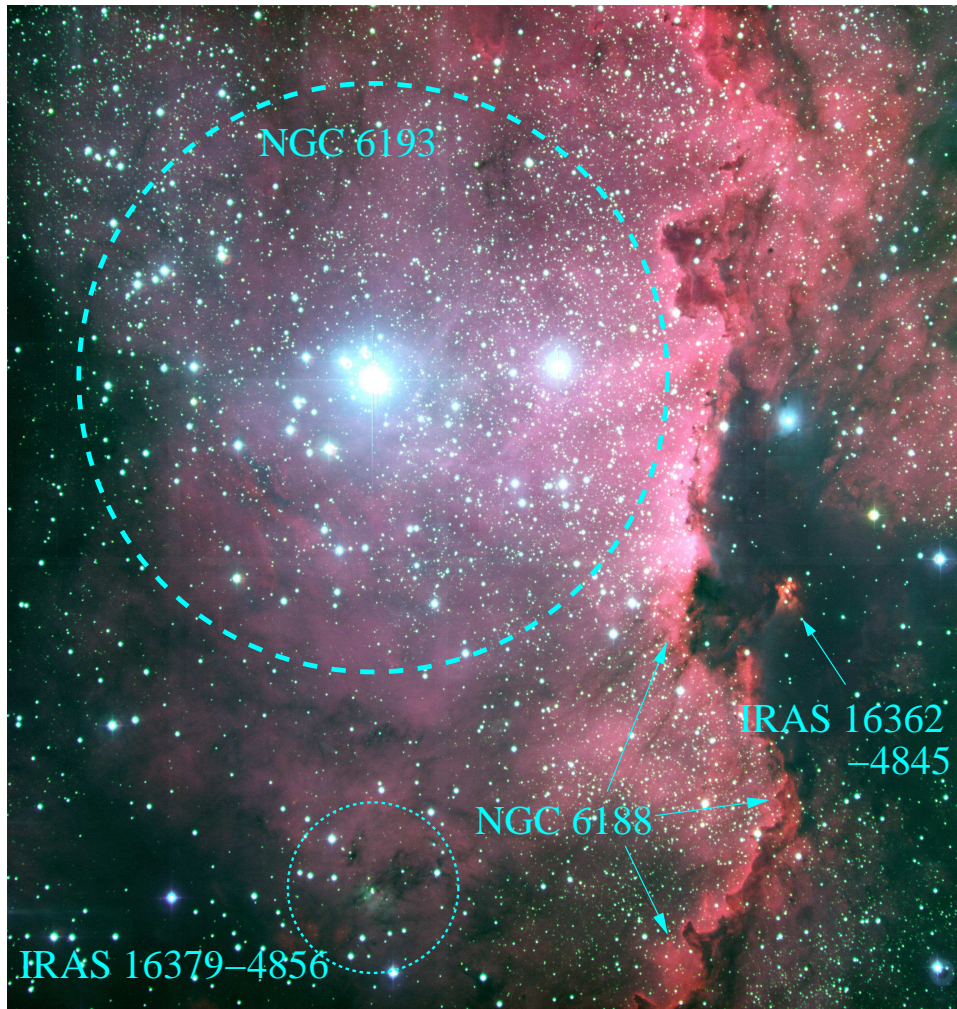


Figure 1. Salient features of the most active portion of Ara OB1a. This image is a B,V H $\alpha$  (blue, green and red respectively) from the wide field imager on the MPI-ESO 2.2m telescope. The field of view is 32'x 32' or about 12 pc on a side.

It has been difficult to obtain a good catalog of stellar members. The 59 stars in Herbst & Havlen (1977) are only identified on a star chart. Similar practices were used by Moffat & Vogt (1973), Arnal et al. (1988) and Vazquez & Feinstein (1992). The deepest published study of NGC 6193 is the *Chandra* zero order image of the *Chandra* gratings observation of HD 150135. HD 150136 is a remarkable O+O spectroscopic binary with a short 2.66 day orbital period (Niemela & Gamen 2005). HD 150136 also has unusual radio properties, being a non-thermal radio emitter (Benaglia, Cappa, & Koribalski 2001) which made it an interesting *Chandra* gratings target in its own right (Skinner et al. 2005). This deep spectrum produces a useful zero-order image. The zero-order data include the central  $2' \times 2'$  region of the cluster. This observation, which should be fairly complete to 1 solar mass, reveals 43 X-ray sources

within 4 square arcminutes (Skinner et al 2005). Only 11 of these had previous optical identifications, however all 43 were detected at H band and are likely cluster members. In addition to those sources cataloged by Skinner et al. there are about 30 X-ray point sources visible outside of the central  $2' \times 2'$  region in this data set. Most of these have I-band magnitudes consistent with cluster membership and are between  $2'$  and  $6.8'$  from HD 150136. Wolk et al. (2008) obtained a 100 ks *Chandra* observation of RCW 108–IR. Due to the orientation of the telescope pointing, about 64 square arcminutes of the NGC 6193 field was covered, mostly to the south and west of HD 150136. These data were a little less than 10 times deeper than the observation of Skinner et al. An additional 99 X-ray sources associated with NGC 6193 were detected. Most of these have infrared counterparts, which supports membership in Ara OB1a. This brings the total identified membership of NGC 6193 up to about 200. But we emphasize the non-uniformity of the data. This is especially true of the *Chandra* pointings which cover perhaps 20% of the area of NGC 6193. A recent shallow *Spitzer/IRAC* map of the region detected about 185 Class II sources, associated with both NGC 6193 and RCW 108–IR, and 13 Class I sources associated with RCW 108–IR alone (Wolk et al. 2008). But this observation was centered on RCW 108–IR and so again does not provide a uniform sample of NGC 6193.

### 3. IRAS 16362–4845/RCW 108–IR

In addition to the NGC 6193 cluster, the nearby source IRAS 16362–4845 harbors the extremely young stellar cluster RCW 108–IR, which has been recently studied (Comerón et al. 2005, Comerón & Schneider 2007, Wolk et al. 2008). The bright rim NGC 6188 marks the border between the HII region and a dense dark nebula containing RCW 108–IR. The bright rim is produced by the ionization of the molecular cloud hosting IRAS 16362–4845 by the two central stars of NGC 6193. The dark cloud contains a high emission measure knot (Wilson et al. 1970), which appears to be a compact HII region (Frogel & Persson 1974). The comprehensive UBVRI study by Herbst & Havlen (1977) proposed this was a site of very recent star formation.

RCW 108–IR is a young, compact cluster partially embedded in its parent molecular cloud. Straw et al. (1987) used photometry at IR wavelengths ( $1.2\text{--}100\ \mu\text{m}$ ) to perform the first spatially complete survey of the cluster. They report on 55 objects;  $< 20$  of these have optical counterparts. In addition to the point sources, there is diffuse IR emission. The total luminosity of the cluster is about  $1.8 \times 10^5\ L_{\odot}$ , dominated by at least two early O stars. The full aggregate of O and B stars appears responsible for the ionization of the diffuse emission (Comerón et al. 2005). The primary exciting source star is identified as IRS 29 (Straw et al. 1987) – probably an O8 star. Straw et al. also identify at least one protostar. They put forward a physical model of the region in which photoionization of the older stars in the Ara OB1a association ionized the bright rim (NGC 6188) which lies at the edge of a finger of molecular material which thickens from east to west (Figure 2).

Several studies at radio wavelengths have been completed to understand the physical properties of the dark cloud. Goss & Shaver (1970) detected continuum emission at 5 GHz, Whiteoak & Gardner (1974) detected  $\text{H}_2\text{CO}$  absorption at 4830 MHz, and CO emission at 115 GHz was detected by Whiteoak & Otrupcek (1982). The hydrogen recombination lines  $\text{H}109\alpha$  and  $\text{H}166\alpha$  were also measured (Wilson et al. 1970; Cersosimo 1982). RCW 108 IRS 29 is the second strongest water source seen by SWAS

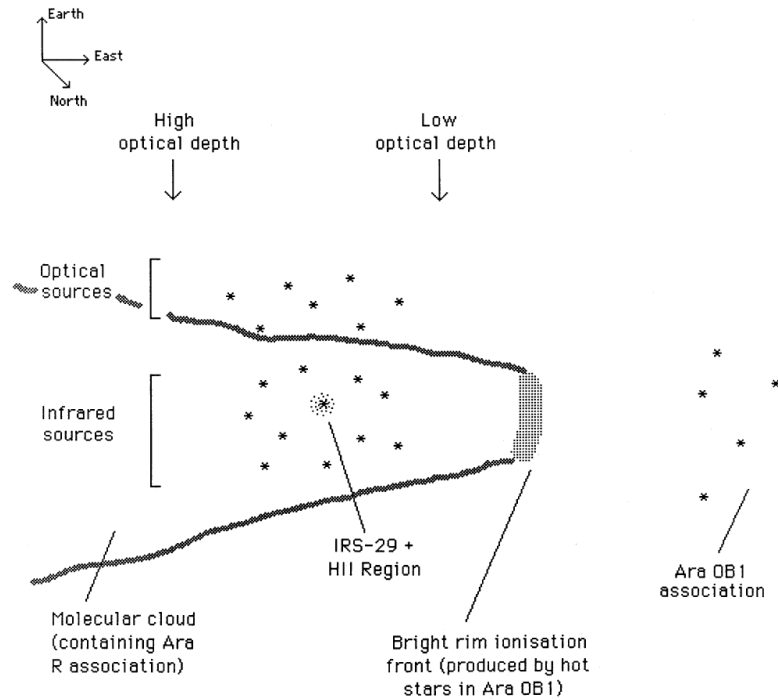


Figure 2. A simple model of the interface between RCW 108 and NGC 6193 from Straw et al. (1987). It now appears that the older stars lie somewhat behind the molecular cloud since none are seen superimposed over it.

(second to the BN object in Orion; Gary Melnick-private communication) with a peak flux of over 7000 Jy in the 557 GHz line. A follow up study suggests that gaseous  $\text{H}_2\text{O}$  is largely restricted to a thin layer of gas near the cloud surface.

There have been two recent near-IR through mm studies of RCW 108-IR. Urquhart et al. (2004) compared the 2MASS and MSX observations of the cloud with radio recombination lines and radio continuum. They find that RCW 108-IR is an ultracompact HII region, less than 0.1 pc in scale with a core-halo morphology. They discuss 8 new sources within the UCHII region and report 3 sources detected at  $25 \mu\text{m}$  and set back about  $2.5'$  from the bright rim. A more detailed study has been recently published by Comerón et al. (2005). From their high resolution CO map they estimate a total mass of the cloud at  $8000 M_\odot$  with  $< 200 M_\odot$  in the molecular concentration harboring the compact HII region. They produced a very high resolution JHK<sub>s</sub> map of the region (Figure 3). They identify 25 stars whose luminosities suggest spectral types earlier than A0 under the assumption that there is no significant circumstellar contribution to the K-band flux and conclude that the ionization of the UCHII region is provided by this aggregate. They suggest that low-mass star formation has yet to commence here. IRS 29 is found to be an O9 star from the visible spectrum of the compact HII nebula, which is in agreement with its infrared photometry. Out of 4365 stars brighter than  $K_s=14.5$  in the whole  $13' \times 13'$  field, 87 are found to have strong disk signatures, most of them located in the molecular cloud that contains RCW108-IR.



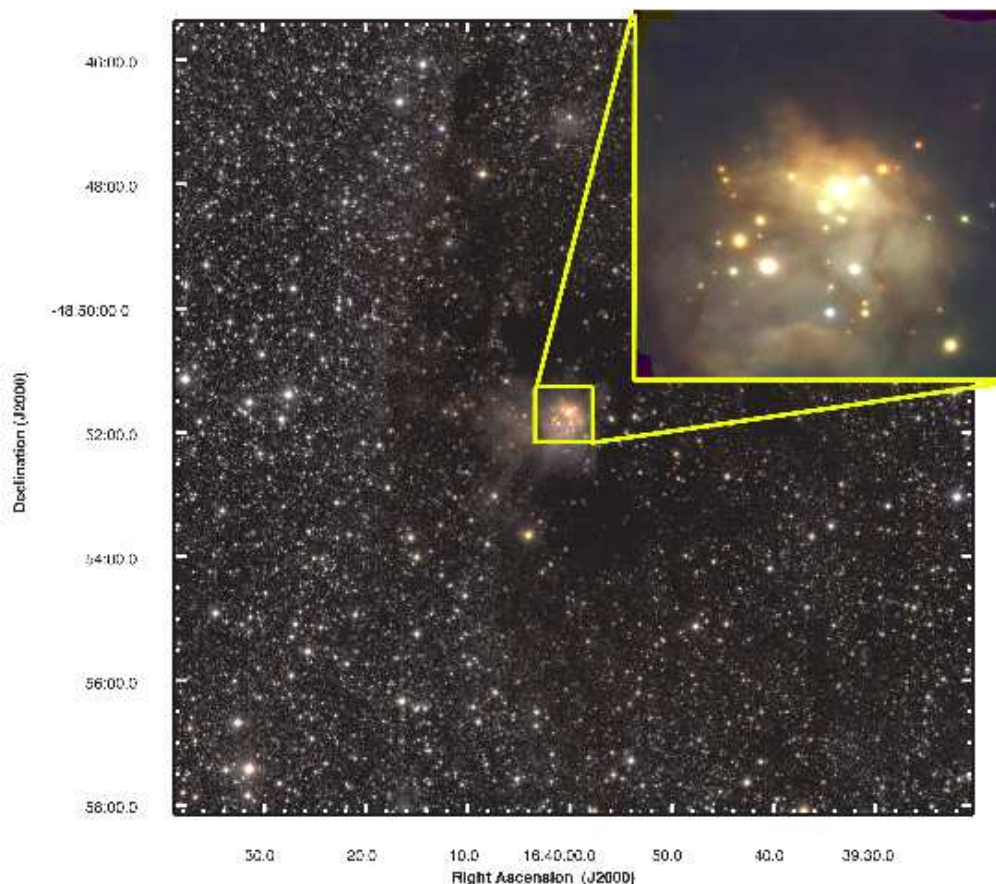


Figure 3. A  $JHK_S$  (blue, green and red respectively) image of RCW 108-IR from the NTT. The field of view is about  $13'$  on a side, corresponding to about 6 pc on a side. Five-sigma detection limits in the least-exposed areas of the image are typically  $J=18.6$ ,  $H=17.7$ ,  $K=17.2$  mag. The cloud is very opaque immediately north and south of the emission nebula. Most of the stars with optically thick disks are either within this emission or along the eastern edge of the cloud. Inset: A  $J$  (blue),  $H$  (green), and  $K$  (red) color composite of RCW 108-IR obtained using adaptive optics at the VLT. The frames are centered on the brightest source in the near-infrared, at  $RA(2000) = 16:40:00.2$ ,  $Dec(2000) = -48:51:40$ . The field is  $52'' \times 57''$ .

In their 100 ks *Chandra* pointing centered on RCW 108-IR, Wolk et al. (2008) detect 32 point sources in the central arcminute, and 65 within the central  $2'$  (Figure 4). They find a sharp rise in the absorption column of  $\log N_H > 21.2$  ( $A_V > 10$ ) for these stars. By contrast X-ray sources associated with NGC 6193 have inferred extinctions between 0 and 5  $A_V$ . About 10 of the 65 sources in the core region do not have counterparts in the deep survey of Comerón et al.

Recent  $JHK_S L'$  observations of the stellar content of RCW 108-IR have been carried out by Comerón & Schneider (2007) using adaptive optics-assisted imaging at the VLT. The superior resolution attained with adaptive optics provides a much more detailed and deep view than those available in previous studies. The deep imaging reveals

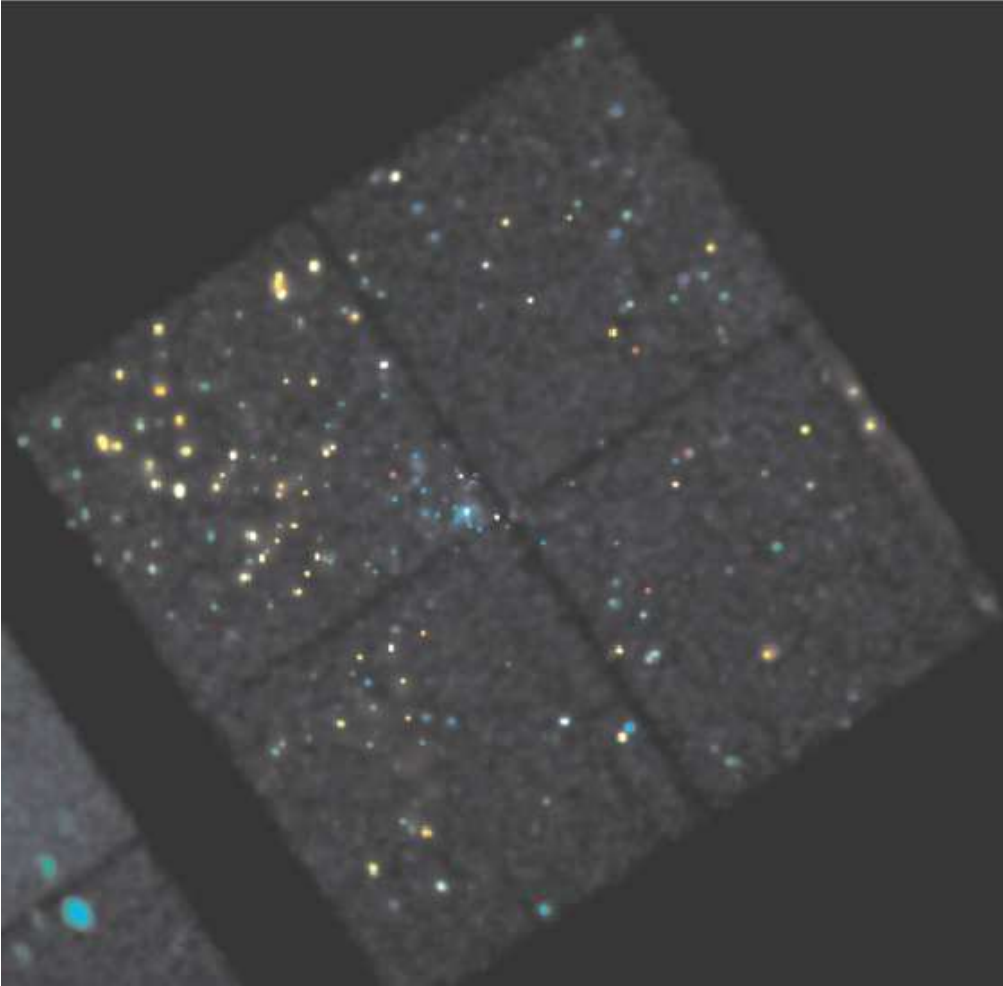


Figure 4. *Chandra*/ACIS-I X-ray map of a somewhat wider region than shown in Figure 3. The colors indicate X-ray energy – red for soft X-rays ( $< 1$  keV), blue for hard X-rays ( $> 2.4$  keV) and green in between. Hard X-rays penetrate gas better than soft X-rays leading to X-ray “blueing” equivalent to optical/infrared reddening. Thus the stars associated with RCW 108–IR appear blue and the stars to the east and south associated with NGC 6193 appear yellow or red. The region is about  $20'$  across. From Wolk et al. (2008).

faint members of the cluster, probably including massive brown dwarfs. This proves that, unlike suggested by Comerón et al. (2005), the cluster does contain low-mass stars. However, such members are present in numbers far below those expected when the bright end of the K-band luminosity function is extrapolated to fainter magnitudes (see e.g. Muench et al. 2002). This is interpreted as evidence for a top-heavy initial mass function, perhaps related to special circumstances that triggered star formation in the cluster (Sect. 6). The revised mass of the cluster based on these new observations is estimated to be  $\sim 370 M_{\odot}$ . Comerón & Schneider (2007) also report the existence of

a point-like Class I source detected only at  $3.8\ \mu\text{m}$ , as well as by *Spitzer*, projected on the border between the HII region and its surrounding molecular cloud.

#### 4. NGC 6204 and NGC 6167

NGC 6204 is an open cluster about 2 degrees northeast of NGC 6193. Whiteoak (1963) identified 78 possible members. He noted a wide variation in extinction, which prevented a good distance estimate. Hogg (1965) identified this clump as two distinct clusters. One cluster is still known as NGC 6204 and is estimated to be at  $1180 \pm 50$  pc. The stars in the other cluster, Hogg 22, are about twice as distant and hence not part of Ara OB1a or Ara OB1b. Forbes & Short (1996) performed photoelectric photometry on 36 member stars of NGC 6204 and find an age of about 125 Myr. This is much older than the other clusters in this region. Thus, these stars are probably not associated unless winds or shocks from extinct stars in this cluster triggered all that followed. The age difference between NGC 6204 and NGC 6193/RCW108-IR seems to safely exclude any role of the cluster in triggering star formation. Even if the velocity difference between the cluster and NGC 6193 were just a fraction of the typical velocity dispersion in a star forming complex, that would already imply that NGC 6204 formed far from its current location and that it was benign (with no stars with strong winds or able to explode as supernovae) by the time it got close to NGC 6193 or RCW 108-IR. Nonetheless, Waldhausen et al. (1999) argue that NGC 6204 is associated with NGC 6193 because their polarization angles are close (about  $15^\circ$ ).

NGC 6167 about 1 degree southwest of NGC 6193 was also poorly defined in the original work by Whiteoak (1963) due to highly variable absorption. Brück & Smyth (1967) identified this as a real cluster at  $1200 \pm 200$  pc and 40 Myr old. Moffat & Vogt (1975) determined a distance of 600 pc, however their argument against the 1.2 kpc distance rests on a single, perhaps foreground, star. Rizzo & Bajaja (1994) assert the age to be closer to 10 Myr. Waldhausen et al. (1999) suggest that this is two overlain clusters since there appear to be two polarizations (offset by  $15^\circ$ ).

#### 5. IRAS 16379-4856 and IRAS 16348-4849

The two IRAS/CO peaks closest to RCW 108-IR are briefly discussed here. To the east is a small diffuse optical nebula near IRAS 16379-4856. Wolk et al. (2008) detect a complex of bright unresolved X-ray emission coincident with this region. A search of the 2MASS catalog for K-band excess sources in this region reveals the strongest concentration of such sources to be associated with this emission, at least 25 sources with K-band excesses in a  $2' \times 1'$  region. These sources all lie on the northwestern portion of a circular ring of  $8\ \mu\text{m}$  emission about  $10'$  in diameter. There are two  $21\ \mu\text{m}$  MSX point sources in the region. One centered among the 25 K-band excess sources, the other located near the inner edge of the ring coincident with the centroid of the IRAS source. This cloud is coincident with region H of the CO survey by Arnal et al. (2003). It is one of three CO clumps coincident with an IRAS source (RCW 108-IR and IRAS 16348-4849 - see below - are the other two). They estimate the mass of the cloud to be  $5800\ M_\odot$ , second only to the core region of RCW 108-IR.

MSX data indicate a mid-IR cloud about  $10'$  west of RCW 108-IR and coincident with IRAS 16348-4849 with a peak  $8\ \mu\text{m}$  flux of about 20% that of RCW 108. The



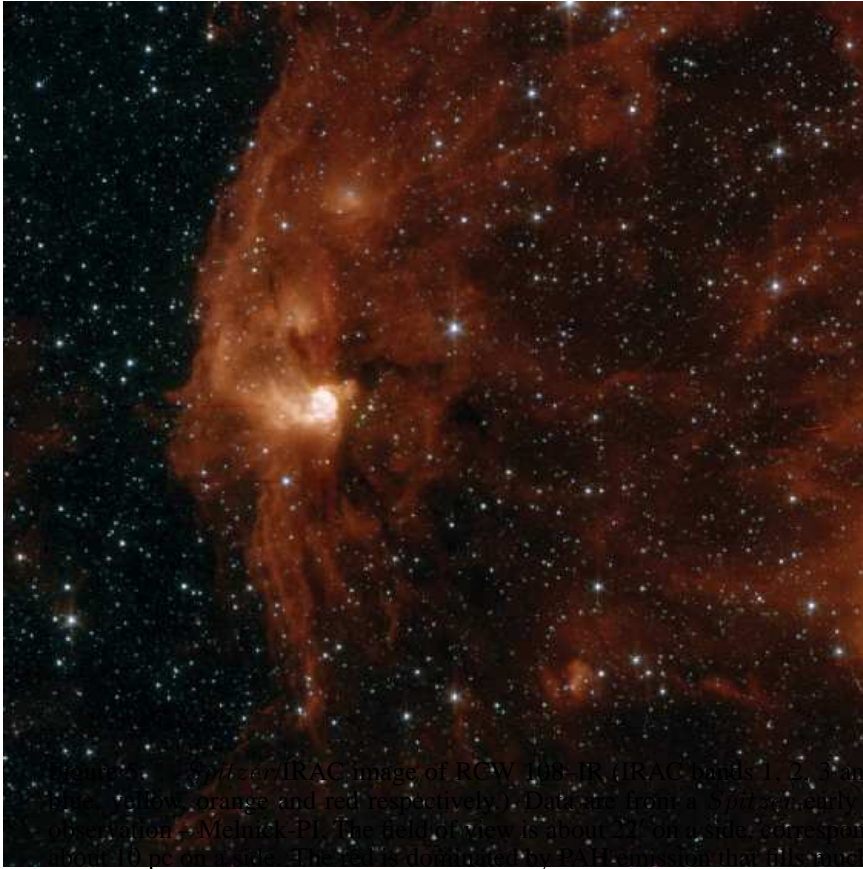


Figure 3. *Spitzer*-IRAC image of RCW 108-IR (IRAC bands 1, 2, 3 and 4 are blue, yellow, orange and red respectively). Data are from a *Spitzer* publicly release observation – Melnick-PI. The field of view is about  $22'$  on a side, corresponding to about 10 pc in size. The image shows a very dark and cold interstellar cloud of the space and shows a deficit of stars in Figure 3. There are slight enhancements in the PAH emission on the southeastern and western portions of the field associated with IRAS 16379–4856 & IRAS 16348–4849. Most of the stars with optically thick disks are either within the core PAH emission or along the eastern edge.

overall extent of the cloud is about  $10'$  on a side. Tendrils of warm dust connecting the cloud and RCW 108 are evident in the MSX and *Spitzer* images. Two sources from the recent  $^{12}\text{CO}$  observations by Arnal et al. (2005) lie within this dark cloud. Five B and A stars have been identified in this cloud; the most massive is the B2IV star HD 149658. 2MASS data show about 20 stars in the cloud with  $K_S < 15$  and K-band excesses indicative of disks. Most of these stars lie within a circular region of  $20 \mu\text{m}$  emission at about 1% the level of RCW 108-IR (Figure 5).

These two regions, like RCW 108–IR, lie between NGC 6193 and the putative center of expansion. IRAS 16379–4856 is almost the same projected distance as RCW 108 from HD 150135/6 at the center of NGC 6193. So, the nominal cluster near IRAS 16379–4856 appears to be a sibling of RCW 108. Likewise formed by photoionization from the OB stars in NGC 6193 striking a cloud which appears to have been swept out by an event related to NGC 6167. The stars near IRAS 16357–4832 appear to compose a sibling cluster as well. The  $8\ \mu\text{m}$  morphology suggests that it was torn off of RCW 108 itself. This cluster is intermediate in mass between the former two. Additional bright CO and  $8\ \mu\text{m}$  emission is visible for a degree north of RCW 108. While the details as described here are speculative at this point, this is clearly a dynamic and active association.

## 6. Triggered Star Formation

It is the morphology of the region that makes Ara OB1a fascinating. NGC 6193 appears in relation to NGC 6188/IRAS 16362–4845 in much the same way that the  $\sigma$  Orionis cluster (Walter et al. 1997, see also chapter by Walter et al.) relates to the Horsehead nebula. The emission in the open cluster is radiation bounded by the molecular cloud containing the embedded cluster RCW 108–IR, and is spectacularly revealed in the figures as a clear ridge between them (NGC 6188; Figure 1). This appears as one of the clearest examples of triggered star formation in the sky. But which mechanism and how it works is still an open issue.

Herbst & Havlen (1977) originally put forward the hypothesis that Ara OB1a was an example of triggered star formation. Their favored model was that the trigger was a supernova event. The *prima-facie* evidence for this was the circular shape of the dust ring upon which RCW 108–IR sits as a “diamond.” Straw et al. (1987) countered with the fact that RCW 108–IR is surrounded by some more evolved objects and point to the bright rim NGC 6188 as evidence that photoionization is very strong in the region. Thus, they favor the model originally detailed by Elmegreen & Lada (1977) in which successive sites of star formation are triggered by photoionization from the previous generation.

Radio observations have much to contribute to this portion of the discussion since the radio data trace the gas and dust before the onset of protostellar collapse. Phillips et al. (1986) mapped the region in CO and find a CO cloud centered 2–3' southeast of the bright stars of NGC 6193. They hypothesize that the cloud is behind NGC 6193 and is being compressed by the winds of the OB stars. However, there is no evidence for embedded sources within this cloud. The fragmented structure of the cloud supports its interpretation as the heavily eroded remnant of a now dispersed, larger cloud, possibly the progenitor of NGC 6193 (Comerón et al. 2005).

Arnal et al. (1987) find a connection between the stellar population of Ara OB1a and an expanding neutral hydrogen ring centered near NGC 6167. The connection is that they derive the same distance to the gas as has been independently determined for the stars of  $\approx 1400\text{pc}$ . At that distance the HI ring is about 30 pc in radius and 20 pc in width expanding at  $10\text{ km s}^{-1}$ . Thus, Arnal et al. derive an upper age of this HI ring of  $2 \times 10^6\text{ yr}$  and an age closer to 1 Myr assuming a wind blown bubble (Weaver et al. 1977). While this is somewhat younger than current age estimates of NGC 6193, the age of NGC 6193 is based on very few stars. If the formation of NGC 6193 were the result of a supernova in NGC 6167 the problem of the age is more severe and in the

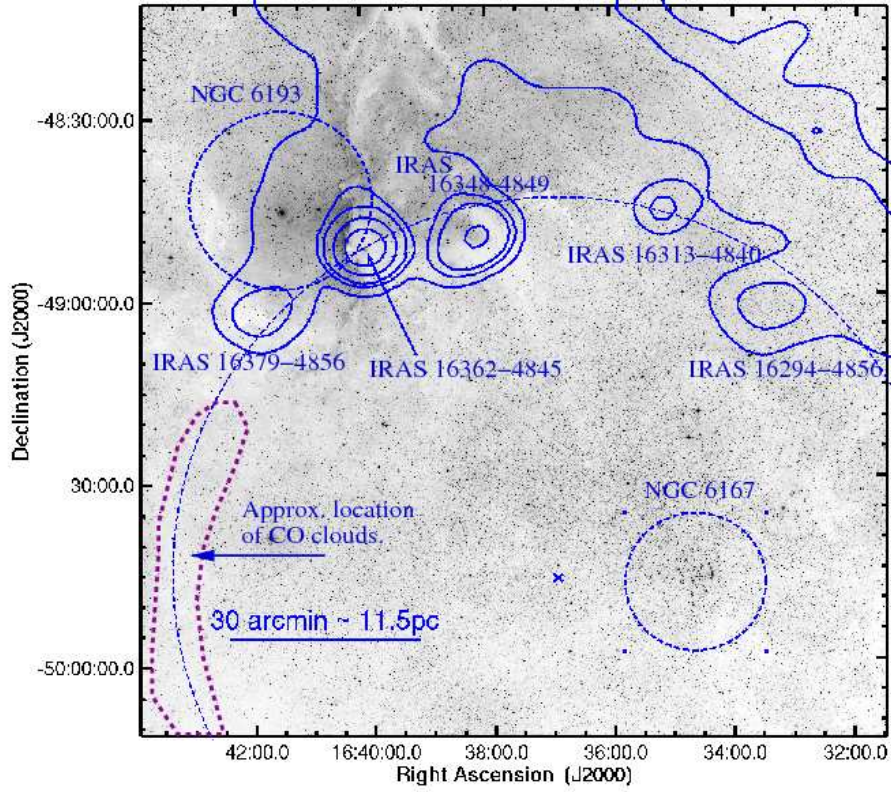


Figure 6. A wide view of Ara OB1a. The base image is a DSS2 red plate about 2 degrees on a side. The top left quadrant is the region shown in Figure 1. The clusters NGC 6193 and NGC 6167 are indicated as well as RCW 108 and several IRAS point sources. The three IRAS sources nearest NGC 6193 all have 8  $\mu\text{m}$  counterparts in MSX data. IRAS 60  $\mu\text{m}$  contours of 300, 450, 600, 1200 and 2400 Jy/Sr are indicated. The large circle is used to connect the various features. There is a chain of CO clouds following along the eastern side of the circle.

opposite sense as NGC 6193 should be quite young,  $\sim 0.1$  Myr, in this case (Straw et al. 1987).

Rizzo & Bajaja (1994) follow up on the Arnal et al. finding with a more detailed HI study. They confirm the initial result. In their model, the 10 Myr stars of NGC 6167 formed the HI shell. This triggered the 3 Myr stars in NGC 6193. In their model the HI shell continues on to trigger RCW 108–IR. However, RCW 108–IR is misplaced in their Figure 6. It seems more likely that photoionization from the stars in NGC 6193 is triggering RCW 108 *in the reverse direction* relative to the outward propagating HI ring. Supporting evidence for external triggering in the clouds that host RCW 108–IR is given by Comerón et al. (2005) who found the cluster members they could identify are not symmetrically distributed throughout the cloud, but clumped along the ionization front as well as the core.

At a smaller scale, Comerón & Schneider (2007) consider that their findings on the stellar population of RCW 108–IR provide evidence that its embedded cluster formed as a result of external triggering. In particular, a top-heavy initial mass function like

that derived by those authors was suggested by Elmegreen & Lada (1977) as a possible byproduct of sequential star formation. This may be a consequence of the warm temperature of the gas in the shocked layer located ahead of the ionization front driven by the hot stars in NGC 6193, as well as of turbulence induced by instabilities in that layer and of coalescence of unstable fragments. Moreover, Comerón & Schneider (2007) also point out that the spatial distribution of massive stars in RCW 108-IR differs from that commonly found in other clusters containing high-mass members, which tend to concentrate towards the cluster center as a result of the formation conditions and early dynamical evolution (Bonnell et al. 2007). This is not expected for externally triggered star formation, and indeed is not observed in RCW 108-IR.

## 7. The Future of Ara OB 1a

Will more star formation take place in Ara OB1a? We believe this is the case and that it is already underway. A recent CO survey of the region finds over a dozen CO clouds in the region covering an area almost 3 degrees on a side (Arnal et al. 2003). While several groups of clouds are kinematically coherent, there is a spread in velocities of almost  $20 \text{ km s}^{-1}$ . Three of the concentrations are adjacent to the bright rim separating RCW 108 and NGC 6193. IRAS data (see Figure 6) show three concentrations of cool dust in the vicinity of RCW 108-IR spaced about 5 pc apart. These concentrations are bright from  $8 \mu\text{m}$  to  $100 \mu\text{m}$ . The brightest of these is RCW 108-IR itself. The IRAS peaks are coincident with  $^{13}\text{CO}$  peaks found by Yamaguchi et al. (1999). The  $^{13}\text{CO}$  peaks then make a chain to the south. Arnal et al. (2003) identify five separate  $^{12}\text{CO}$  features in this cloud. The chain extends almost  $1.5^\circ$  south of RCW 108-IR. In fact, the CO peaks taken in concert with the 5 IRAS peaks (including IRAS 16379-4856 and IRAS 16348-4849 adjacent to RCW 108-IR) cover almost exactly 180 degrees of arc in a near perfectly circular alignment  $1.03^\circ$  from  $l=335:29:12$   $b=-1:42:23$ , about 8 pc from the center of NGC 6167. More specifically, Comerón et al. (2005) estimate a current star formation efficiency in the main cloud hosting IRAS 16362-4845/RCW 108-IR to be well below 10%, suggesting that most of star formation in the cloud still has to take place. They also speculate that its future evolution may lead to a complex similar to the Orion Nebula Cluster, with the aggregate of IRAS 16362-4845 being the equivalent to the Trapezium cluster.

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